THE RELATIONSHIP BETWEEN PRACTICE TIME AND SLEEP IN COLLEGIATE ATHLETES

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ABSTRACT

Alexandra Lovgren: The Relationship Between Practice Time and Sleep in Collegiate Athletes (Under the Direction of Meredith Petschauer)

Objective: To analyze differences in sleep quality and quantity between collegiate athletes routinely practicing at different times of the day. **Participants:** 24 male collegiate athletes from the Men's Lacrosse, Baseball, and Men's JV Basketball teams. **Methods:** Participants were divided into morning, midday, and evening cohorts based on their respective team practice times. Sleep quantity and quality were measured daily via online questionnaire (Qualtrics) for 27 days of pre-season practices. Participants reported bedtime, wake time, and ranked sleep quality. Weekly sleep quality was measured via PROMIS sleep disturbance short form via online questionnaire (4 measurements total). **Results:** There were no significant differences in practice time and reported sleep quantity ($F_{(2,21)} = 1.045$, $p = .369$) and sleep quality ($F_{(2,21)} = 0.534$, $p = .594$). **Conclusion:** Based on results of this study, there appears to be no association between practice time and sleep quantity and quality. Further research is recommended.

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CHAPTER 1

INTRODUCTION

In the general population, sleep is considered a basic requirement of health.[1] Sleep is believed to be important in athletics, as it has been shown to play a significant role in preparation, performance, and recovery.[1–3] However, little is known about the relationship between sleep and training time. One factor believed to affect sleep is the time of day training and competitions occur.[2,3] Training at times that interfere with sleep may be harmful to athletes, as performance might be negatively impacted.[1] Proper understanding of how training time will effect sleep, which in turn affects performance, would be beneficial for creating an optimal training schedule.

In assessing practice time's effect on sleep, the timing can be thought of as morning, midday, and evening training. Often, collegiate team practices will occur throughout these different times of day, possibly due to multiple teams requiring use of the same facility, coaching staff and athlete scheduling conflicts, or various other reasons. With practices occurring at multiple times throughout the day, it is worth understanding any differing effects between the practice times. Morning training has been shown to result in decreased sleep and increased pre-training fatigue.[3] Late competitions also lead to diminished sleep.[2] If reduction in sleep is linked to poor performance, these early morning or late evening training sessions may need to be reconsidered.[1] Alternatively, no studies exploring the effects of midday practice on sleep have been found.

Recovery is also affected by diminished sleep, as sleep facilitates recovery from the mental and physical demands of high-performance sport.[4] Multiple recovery related metabolic processes, such as energy conservation and nervous system recuperation, occur during sleep.[5,6] If decreased sleep impairs recovery, then avoiding situations leading to decreased sleep should be desired by both athletes and coaches.

There is a large deficiency in research concerning sleep and athletic participation. When assessing available research, limitations exist due to small sample sizes and lack of diversity of athletes utilized by studies.[7] Normal sleep needs of athletes are unknown, which make it difficult to assess the minimum sleep athletes require.[1,3,8] Sleep needs and trends observed in the general population are often applied to the athletic population as a result of this lack in knowledge. In the general population, 7-9 hours of sleep per night is recommended in order to function well during daytime activities.[3,6,9,10] When this recommendation is not met, various negative cognitive, social and behavioral, and health outcomes occur.[11–14] The purpose of this study is to analyze the effects of different training times on sleep quality and quantity in athletes at a division 1 institution.

Clinical Significance

Understanding an athlete's training schedule and its relationship with sleep can be used to drive training scheduling. Training at times of the day that lead to diminished sleep, and therefore diminished performance, could be avoided. Diminished performance is cause for concern; as a small decrease in performance may be the difference between winning or losing a competition.[15] Training at a time that promotes the best sleep will also promote optimal preparation and recovery. This information is valuable to coaches, strength and conditioning staff, and medical personnel.

Questions and Hypothesis

Question 1: Is there a significant difference in average reported sleep quantity between collegiate athletes who practice in the morning, midday, or evening?

Hypothesis 1: There is a significant difference in practice time and reported sleep quantity.

Question 2: Is there a significant difference in average reported sleep quality between collegiate athletes who practice in the morning, midday, or evening?

Hypothesis 2: There is a significant difference in practice time and reported sleep quality.

CHAPTER 2

LITERATURE REVIEW

Introduction to Sleep

Sleep is a fundamental biological process and is essential for recovery, energy conservation, and survival.[1,4,10,16] Humans will spend about 1/3 of life sleeping, where a multitude of functions, both cognitive and biological, will occur.[7,17–19] There is a growing body of scientific evidence demonstrating this connection between sleep, cognitive processes, and metabolic processes.[5] Current evidence suggests it is linked to memory consolidation, neural development, and learning.[5,10,20] As such, loss of sleep can affect mood and performance of mental tasks.[11–13,15] Negative effects on mood and performance can be seen after as little as 2 to 3 hours lost per night.[13,15] In rat models, Rechtschaffen et al. observed occurrence of mortality following 11-32 days of total sleep deprivation or 16-54 days of partial sleep deprivation.[16] In light of these findings, it was suggested that sleep deprivation negatively affects human survival but possibly at a different rate.[16] Despite a lack of understanding as to "why" humans require sleep, there is a greater understanding of how humans sleep.[7,17]

Architecture of Sleep

Human sleep can be viewed as two main architectural, or structural, categories: rapid eye movement (REM) and non-rapid eye movement (NREM).[6,21] During these categories of sleep, critical metabolic and immune processes are known to occur.[5] In addition to rapid eye movement, REM sleep is characterized by skeletal muscle paralysis, muscle twitching, cortical activation, and vivid dreaming.[19,22,23] REM sleep shows periodic brain activation and is believed to be important in the localized recuperative process and emotional regulation.[6]. NREM sleep is believed to be important in energy conservation and nervous system recuperation.[6,7] NREM can be further subdivided into 4 stages.[7,21] Stage 1 is a shift stage from awake to asleep, lasting a few minutes, and is characterized by the presence of theta wave activity.[24,25] Following this shift stage is stage 2, which is characterized by the presence of sleep spindles and K complexes.[24] Stages 3 and 4 are often combined and referred to as slow wave sleep (SWS).[6,21,24] SWS is recognized by the presence of delta waves and high-voltage slow-wave activity.[6,21,22,24] SWS has been thought to be important in restoration since 1970.[21] When utilizing rat models, Xie et al. reports the observance of a significantly increased rate of metabolic waste products removal from the interstitial space of the brain during SWS sleep.[26] This clearance of waste products, which may potentially be toxic to neural cells, is essential in restoring and maintaining homeostasis of cells.[26] In support of this relationship, it has been observed in athletics that time spent in SWS will increase following increases in training load.[21] While sleeping, REM and NREM sleep will be cycled through in 90 minute increments, with NREM constituting about 75-80% of a sleep cycle.[6,7,24] For example, an individual who sleeps 9 hours should cycle through NREM and REM six times total.

In addition to the REM and NREM processes occurring during sleep, there are hormonal events taking place during sleep. These hormones play a role in the sleep-wake cycle. Melatonin is a hormone whose production is regulated by an internal clock via a day-oriented schedule.[27,28] Secretion of melatonin begins in the evening, peaks in the middle of the night, then reaches lowest levels of secretion by morning.[27] Peak melatonin often occurs between 3:00 and 4:00 am, but this will have variation.[28] In a meta-analysis consisting of 19 randomized placebo control studies, Ferracioli-Oda et al. found that subjects given melatonin had significantly reduced sleep latency, or the time needed to initiate sleep after going to bed, as well as significantly increased sleep quantity and quality compared to placebo subjects.[29] This observation of an interaction between melatonin and sleep supports the role of melatonin in sleep regulation. In addition to melatonin, cortisol follows a day-oriented schedule, with peaks at wake time and low levels observed during the first hours of nocturnal sleep hours.[27] This peak in cortisol levels following awakening is often referred to as the cortisol awakening response.[30] Due to the low cortisol levels observed during sleep and the cortisol awakening response occurring within one hour of awakening, it is believed cortisol is involved in arousal and energy boosts.[30] Both melatonin and cortisol appear to have roles in the regulation of sleep and awakening. The regulation of these hormones is interrelated to circadian rhythm, as both occur on a daily schedule.

Phasing of Sleep

When assessing sleep, understanding different patterns associated with sleep is important. These patterns include chronotype and circadian rhythm. Chronotype refers to the tendency of individuals to be either early wakers, later wakers, or intermediate wakers.[31] Chronotype is the preferred timing of sleep and awakening.[32] Chronotype preferences will correspond to circadian rhythm.[32] Circadian rhythms are directly related to the sleep wake cycle, as well as other aspects of human functioning.[33] Daily exposure, such as light-dark exposure, entrains circadian rhythm.[27,34] Other environmental factors affecting circadian rhythm include temperature, noise, and food consumption.[35] This entrained circadian timing will affect the quantity and quality of sleep.[5] It can be difficult for individuals to match actual sleep schedule and preferred circadian rhythm. External cues, such as school, work, and social commitments, will influence circadian rhythms, possibly disallowing circadian rhythm and actual schedule from matching.[5,33] Chronotype and circadian rhythm are interrelated, as individuals presenting as early waker chronotypes will have advanced circadian rhythm, while later waker chronotypes display a delayed circadian rhythm.[33] Circadian rhythm and chronotype will dictate an athlete's sleep preferences, yet practice and game schedules most likely do not take into account the sleep preferences of every participating athlete.

Measurements of Sleep

Often, sleep is broken into quantitative and qualitative components to allow more detailed assessment and measurement. Guidelines outlining "normal" or "typical" sleep in terms of quality and quantity are relatively new, as there is a deficiency in the understanding of what constitutes good sleep.[36]

<u>Quantity</u>

Total sleep quantity is the sum of night time sleep and daytime naps.[37] When measuring sleep quantity, time in bed and sleep latency must be considered. Time in bed is the difference between bed time and wake-up time, while sleep latency is the difference between time to bed and time of true sleep onset.[1] Higher sleep latency would indicate a subject lying down for sleep but not falling asleep. For example, an individual sets a bedtime that allows 8 hours of sleep, but when the individual lays down they are unable to fall asleep for 45 minutes. Only 7.25 hours of sleep is obtained, rather than the intended 8 hours. This example shows how a sleep latency of 45 minutes is a hinderance against desired sleep quantity. In addition to trouble falling asleep, awakening throughout the night and/or in the early morning will also decrease total sleep quantity. Because quantity of sleep may be impacted by quality of sleep, quality must be explored.

The National Sleep Foundation (NSF) recommends 7-9 hours of sleep per night, a recommendation decided upon by a multidisciplinary expert panel comprised of sleep experts as well as experts in other areas of medicine, physiology, and science.[9] This 7-9 hours per night recommendation is further supported as a large percentage of the population functions well with 7 to 8 hours of sleep.[3,6,10] Ohayon et al found about 75% of participants in a sample derived from 15 U.S. states (n = 15,929) report sleeping between 6 and 8 hours per day.[38] A wide range of accepted healthy sleep quantity (7 to 9 hours) is provided, because sleep quantity requirements are somewhat individualized and change over time.[7,10] For example, Ohayon et al found that young adults (18-24 years old) and the elderly (≥65 years old) reported sleeping greater than 9 hours per 24 hour day significantly more frequently than all ranges between 24 and 65 years old.[38] As humans develop and age, different periods of life coincide with different sleep structures and requirements.[39] Due to these changes in sleep, the NSF has reported guidelines based on age categories, such as the recommendation for young adults (18-25 years old) is 7-9 hours of sleep per day.[9] Other recommendations from the NSF range from 14-17 hours of sleep per day for newborns (0-3 months old) to 7-8 hours of sleep per day for older adults (≥65 years old).[9] As sleep in collegiate athletes is discussed, it should be remembered that the recommendation for this age group (18-25 years old) in the general population is 7-9 hours of sleep per night.

In contrast to the recommended 7 to 9 hours, short sleep (6 or less hours) has been linked to adverse outcomes.[10,40] The observed expression of these adverse outcomes may vary depending on the population in which outcomes are assessed. In the general population, adverse outcomes are often categorized into cognitive, social and behavioral, and health outcomes.[11–14] In the athletic population, the adverse outcomes of interest often relate to athletic preparation, performance, and recovery.[1,3,41]

Aside from short sleep, excessive quantity sleep is linked to the presence of other conditions.[38,42] Excessive quantity sleep (EQS) is defined as attaining too much sleep, or more specifically sleep that is greater than 9 hours per 24 hour day and causes disruptions and distress in daily life.[38,42] EQS may occur due to an existing sleep disorder, such as insomnia disorder.[38] If an individual's sleep is insufficient for any reason, the individual may attempt to compensate by sleeping longer and more often in one 24 hour period. EQS may occur in concurrence with other conditions, as reported by Ohayon et al.[42] In an unspecified sample of 18,980 individuals, those with bipolar disorder, generalized anxiety disorder, obsessive-compulsive disorder, and panic or post-traumatic stress disorder were twice as likely to report EQS.[42] Research into EQS is relatively new and continuing to progress.[38,42] Given that sleeping too long or too short seem to have detrimental effects, quantity sleep warrants further investigation.

Quality

The term sleep quality may be used to suggest an aspect of sleep that is separate from sleep quantity, as this does not fully illustrate the sleep experience.[6,10,43] There is no single, clear cut definition of sleep quality, but more commonly used definers of quality are subjective reports of sleep experience, subjective reports of perceived sleep adequacy, and/or subjective reports of satisfaction with sleep.[6,37,39,43] While these methods of defining sleep quality are subjective, breaking sleep quality into measurable objective components will allow more ease in defining and assessing it.[39]

Objective components that may be used in defining and assessing sleep quality include the ability to initiate sleep and the ability to maintain sleep.[37,43] In addition to being used in describing quantity, sleep latency, a measurement of one's ability to initiate sleep, is also used in evaluating quality. Higher sleep latency is associated with decreased sleep quality.[36,37] Therefore, sleep latency may potentially be used as an indicator of sleep health.[36] Along with sleep latency, total wake time throughout the sleep period and sleep efficiency affect sleep quality.[43] Total wake time throughout the sleep period and sleep efficiency represent an individual's ability to maintain sleep. Summing all wake period lengths will equal total wake time throughout a sleep period. Sleep efficiency is expressed as the actual total time asleep percentage of the full sleep period.[3] This equation is written as (total sleep time ÷ time in bed) × 100, with the final value expressed as a percentage.[36] Sleep latency, total wake time throughout a sleep period, and sleep efficiency are tools often used in assessing sleep quality, as is the occurrence of non-restorative sleep.

Further subjective indicators of sleep quality are the occurrence of non-restorative sleep and sleep fragmentation.[1,43] Nonrestorative sleep is defined as the perception of not feeling refreshed the next morning.[8,37,44] This sleep is adequate in quantity yet inadequate in quality and can be the result of sleep disturbances, such as awakening throughout the night.[5,44] Subjective feelings of restless sleep, low quality sleep, daytime sleepiness, and decreased performance are results of nonrestorative sleep.[44] Sleep fragmentation may also disrupt sleep quality.[1,43] Sleep fragmentation is recurrent arousal without full awakening from sleep.[5] Sleep apnea illustrates these symptoms of sleep fragmentation, arousal without full awaking.[45] Changes in REM and NREM sleep architecture, such as decreased SWS sleep, may accompany fragmentation, but these changes are not required when diagnosing fragmentation.[45] Consideration of sleep quality in addition to sleep quantity is important, because increased sleep quality is a predictor of good physical and mental health, wellness, and overall vitality.[39]

<u>Measurement Tools</u>

When measuring sleep, there are many different tools that may be utilized. These tools can be divided into objective measures and subjective measures. Objective measures are those in which technology or study personnel monitor the study participants sleep, allowing the participants own feelings and conceptions to be removed. Subjective measures allow the subject to monitor, record, and comment on their own sleep. This self-monitoring opens the possibility for inaccuracy. There are benefits and drawbacks associated with both objective and subjective measures.

Objective measures of sleep include polysomnography and wristwatch actigraphy. Polysomnography is considered the gold standard in assessing sleep.[1,3,8,43] Polysomnography measurement of sleep requires the use of electroencephalogram (EEG), electro-oculogram (EOG), and electromyography (EMG) at minimum.[46] Electroencephalogram, electro-oculogram, and electromyography are electrophysiological readings of brain activity, eye activity and muscle activity, respectively.[47] These tools are then used to measure sleep. A number of measures are taken when polysomnography is employed, such as sleep onset latency, total sleep time, awakenings occurring during the sleep period, and amount of time spent in the various stages of sleep.[43,46] For example, increases in measured brain activity throughout the night will equate to awakenings throughout the night.[47] These measures can be used to assess the architecture of the subject's sleep, such as measured eye movement indicating phasing (NREM and REM) of sleep.[43,47] Despite being considered the gold standard, polysomnography is not always utilized in studying sleep in sports. This is due to the high costs, need for a lab and specialists, relative intrusiveness, and resulting high stress on those being tested.[1,8] Notably, when utilizing polysomnography, the subjects sleep in the lab containing the necessary equipment, which can cause the subjects stress as they sleep in this new setting. In place of polysomnography, wristwatch actigraphy may be utilized. This method has decreased cost, decreased burden on subjects, and can be employed for long durations of time.[43,46] Wristwatch actigraphy uses movement of the subject to determine whether the subject is awake or asleep.[43] Movement as a primary measure may be problematic, as the subject may not be moving but also may not be asleep.[43] This state of not moving and not asleep may occur when the subject is watching television or is lying in bed but not yet asleep. Despite this shortcoming, wristwatch actigraphy has been found to have 80% accuracy when compared to polysomnography.[1] The best supported use for wristwatch actigraphy is characterizing a subjects pattern of sleep and wake times, not sleep onset latency or sleep efficiency.[43] It should be noted that factors not well supported for measurement by wristwatch actigraphy are the same factors commonly seen in measurement of sleep quality. For this reason, this tool may be best used when assessing sleep quantity.[43] Regardless of the shortcomings of wristwatch actigraphy, this tool is better suited than polysomnography for studying the athletic population.[1] The convenience of wristwatch actigraphy and a reduced impact on the athletes' schedules may increase the viability of utilizing this tool in the athletic population. Polysomnography and wristwatch actigraphy are two objective tools for assessing sleep, but there are many more subjective tools commonly utilized when assessing sleep.

The Pittsburg Sleep Quality Index (PSQI) is frequently used when researching sleep.[2,20,31,48] This self-rating questionnaire was introduced in 1989 as a tool to differentiate "good" and "poor" sleepers and has been used extensively in sleep evaluation for over 25 years.[48–51] The PSQI provides a measure of global sleep health quality based on subjects' retrospective assessment of their last 1 month of sleep.[43] To do this, the PSQI assesses several domains of sleep via seven components: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleep aid medications, and daytime dysfunction.[51,52] This questionnaire results in a score from 0 to 21, can be completed in 5-10 minutes, and scored in 5 minutes.[49,51] Using a stratified sample (n = 148) of healthy adults, those diagnosed with depression, and those diagnosed with disordered sleep, Buysse et al. found the PSQI to have internal homogeneity, test-retest reliability, and discriminant validity.[51] In testing validation of the PSQI in an undergraduate collegiate population (n=866), Dietch et al. found the PSQI has moderate convergent validity and good discriminant validity.[52] These findings led to the recommendations that the PSQI is well suited for detecting insomnia and fatigue complaints, but additional tools should be utilized in diagnosing insomnia as well as in detecting daytime sleepiness complaints and circadian preference.[52] While there are benefits to utilizing the PSQI, there are also drawbacks. One limitation of the PSQI is the lack of specialization to the athlete population.[4] If unfamiliar with the tool, the PSQI can be difficult to score.[49] The PROMIS (Patient Reported Outcome Measurement Information System) sleep disturbance short form is another subjective questionnaire consisting of 8 items.[53–55] This tool was developed through a process of literature review, pilot testing, and psychometric testing as a mean of measuring sleep quality in many different samples.[53] The PROMIS sleep disturbance short form questionnaire's purpose is to assess the severity of sleep disturbance on a continuum, with a higher score representing greater impairment.[54,55] This questionnaire is designed to assess sleep quality, perceived adequacy of sleep, and difficulties falling asleep and staying asleep.[55] When using a sample of 1993 participants and comparing against the PROMIS sleep disturbance long form, the PSQI, and the ESS, Yu et al. found the sleep disturbance short form to have construct validity and reliability.[54] This questionnaire is not intended for use in diagnosing sleep disorders.[54,55] Other subjective questionnaires that may be utilized include the Epworth Sleepiness Scale (ESS), the Profile of Mood Sates (POMS), and the Horne and Osteberg Morning/Eveningness Questionnaire. [2,12,21,31] These questionnaires are less commonly used in assessment of sleep quality, because they are meant to assess for specific conditions rather than overall sleep health, such as the ESS specializing in daytime sleepiness.[56] The STOP-BANG questionnaire for obstructive sleep apnea is composed of 8 questions (4 symptom related and 4 demographic) aimed at determining the likelihood that an individual experiences obstructive sleep apnea.[57,58] Chung et al. reports the STOP-Bang questionnaire is concise, effective, and reliable in assessing for obstructive sleep apnea.[57] An additional subjective measure of sleep is a sleep diary, in which subjects record their believed time to bed and time awake.[12,31] However, sleep diaries have shown poor accuracy when compared to more objective actigraphy results, as subjects tend to report significantly higher sleep quantities in sleep diaries.[12,59] Often, time asleep and time in bed are not clarified as to separate values which biases data towards higher sleep duration.[9] One common component of sleep diaries is a Likert-style rating of the previous night's sleep quality.[43] The Stanford Sleepiness Scale (SSS) and the Karolinksa Sleepiness Scale (KSS) are 2 Likert-style rating tools that have been specialized for sleepiness. In employing both the SSS and KSS in the same study, results of the two scales were nearly identical.[13] While there are many subjective tools that may be used in assessing sleep quality, none of these are specific to the athletic population.

Subjective sleep questionnaires aimed at better assessing athletes have begun to emerge. The Athlete Sleep Screening Questionnaire (ASSQ) has been developed as a screening instrument to detect clinically significant sleep disturbances and daytime disfunction in the athlete population.[4] Using 199 Canadian National Teams, Bender et al. found the ASSQ to have poor internal consistency (Cronbach's $\alpha = 0.58$), a sensitivity of 81%, and a specificity of 93%.[4] Another tool still in development, the Athlete Sleep Behavior Questionnaire (ASBQ), is used to identify maladaptive sleep behaviors in athletes.[4,60] In a sample of 564 participants (athletes n = 242, non-athletes n = 322), Driller et al. found the ABSQ to have moderate to large correlation with existing validated sleep questionnaires, acceptable levels of reliability, and the ability to successfully differentiate between athlete and non-athlete.[60] These questionnaires aimed at assessing athletes appear to show promise, but are relatively new and, therefore, lacking in utilization.

Subjective measures have an overarching drawback: subjects are unconscious during sleep and are, therefore, poor observers of their own sleep.[39] To manage this limitation some studies have employed two questionnaires, such as administering both the PSQI and the Competitive Sports and Sleep Qestionnaire.[2] However, it has been noted that when utilizing two different questionnaires, the results of the two questionnaires do not always correlate.[2] This may show a lack in convergent validity. Subjective questionnaires have shown poor correlation with objective methods of study.[1] It may be worth employing more than one questionnaire to allow the greatest amount of information to be obtained. Utilizing subjective measurement tools can be cost efficient, time efficient, and cause less subject stress, but testers must be aware of the previously noted disadvantages. Both objective and subjective measures display pros and cons, which must be weighed by investigators when choosing methods to study sleep.

Sleep in the General Population

Understanding negative sleep trends commonly seen in the general population is important to properly understand any challenges or differences the athletic population faces. In the general population, sleep trends can be observed through a multitude of events, such as occurrence of sleep latency and nonrestorative sleep.

Sleep latency of 15 minutes is considered appropriate in the general population, as decided upon by the National Sleep Foundation's Sleep Quality Consensus Panel.[39] As previously stated, increased sleep latency indicates reduced sleep quality, therefore occurrences of sleep latency greater than 15 minutes in the general population indicates poor sleep.[36,37] Increases in sleep latency are linked to increased nonrestorative sleep.[44] Therefore, the occurrence of nonrestorative sleep can be used to observe sleep trends.

Through a sample of 25,580 general population members of 7 European countries, Ohayon et al. concluded nonrestorative sleep to occur in approximately 10.8% of the general population.[44] This shows a trend in which 10.8% of the general population awakens with the perception of not feeling refreshed in the morning.[8,37,44]

Sleep restrictions, or partial sleep deprivation, is another observable parameter.[61] Accumulated restrictions in sleep can accrue over several days leading to acute or chronic fatigue and sleepiness.[27] If sufficient recovery time is not allotted following sleep reduction, then acute and chronic fatigue will occur.[27] One possible source of sleep restriction is awakening multiple times throughout the night. The National Sleep Foundation's Sleep Quality Consensus Panel has concluded a normal number of awakenings during a single sleep period is one or less.[39] Further sleep recommendations from the National Sleep Foundation's Sleep Quality Consensus Panel are normal sleep efficiency is considered 85% or greater and normal time spent in REM per night is 21-30% of time asleep.[39] Sleep that meets these norms is frequently high quality sleep as well.[39]

PSQI scores may also be used to assess sleep trends, with a PSQI score below 5 indicating good quality sleep and scores above 5 indicating poor sleep.[51] When comparing 45 healthy controls to 80 patients diagnosed with primary insomnia, Backhaus et al. found the 45 healthy controls' PSQI scores to fall beneath this 5 point threshold (3.3 ± 1.8) while the patients diagnosed with primary insomnia reported PSQI scores above the threshold (12.5 ± 3.8).[49] When assessing the normal measurements observed in general population sleep trends, certain subsets of the population should be delineated to allow a better understanding of what affects sleep trends in the general population.

Further delineation of the general population allows assessment of sleep based on age and biological sex. As previously mentioned, sleep structure and requirements change with age, such as infants differing from the elderly in sleep quantity.[9,39] In addition to sleep quantity differences among age groups, other qualitative measures will differ between ages. In the general population, young adults show high levels of daytime sleepiness.[62] The old (55 years and older) experience nonrestorative sleep more frequently than younger populations.[44] Along with these age related differences in sleep, there are biological sex differences. It has been found that men and women tend to show significant differences in sleep, such as decreased sleep efficiency.[1,37] Goel et al. found using polysomnography in a sample of 31 subjects (women n = 15, men n = 16) that women had significantly greater total sleep time and significantly better sleep efficiency.[63] In a sample of 52 participants (women n = 29, men n = 23), Hume et al. found that women experience more SWS sleep than men.[64] While increased total sleep time, increased sleep efficiency, and increased SWS sleep are positive differences in sleep experienced by women as compared to sleep experienced by men, other research indicates women may be experiencing negative sleep differences as compared to men. One negative outcome experienced by women is the increased frequency of experiencing nonrestorative sleep as compared to men[44] There are a variety of reported differences in sleep between biological sex and between different age groups, as well as differences resulting from other factors. Despite this evidence, there is ongoing debate as to whether or not gender differences exist in sleep measures, with studies reporting no differences between gender.[18,36]

Aside from the naturally occurring differences in sleep due to age and sex, there are observable differences in sleep resulting from social and behavioral decisions. Smoking and alcohol consumption at or near bedtime have been linked to increased nonrestorative sleep.[44] In addition to smoking and alcohol consumption, other lifestyle habits, such as irregular mealtimes and high screen (cell phone, TV) use, are risk factors for sleep disorders.[65]

The negative impacts of insufficient sleep can be categorized into cognitive, social and behavioral, and health outcomes. Cognitively, decreases in reaction time, memory tasks, and learning tasks are seen following experimentally restricted sleep.[12,45] Restriction of sleep to 4 or 6 hours per night for 14 days, compared to those sleeping 8 hours, resulted in significantly decreased cognitive performance as measured by the psychomotor vigilance task (PVT), a computerized digit symbol substitution task, and a serial addition/subtraction task.[13] Social and behavioral outcomes of decreased sleep include a behavioral profile of social withdrawal and loneliness.[11] In a study utilizing the Diagnostic Interview Schedule, 2,570 subjects of those who reported excessive sleepiness also reported greater rates of missing social and family commitments, as well as reporting greater rates of depression.[14] Bonnet et al. reports following sleep fragmentation or sleep loss, mood will be negatively affected (possibly seen as increased irritability, increased stress, or increased confusion).[45]

Investigations into the effects of shiftwork on the general population has allowed an understanding of detrimental sleep in the general population. Work schedules extending beyond the typical 9 to 5 workday are considered shift work; these schedules often comprise of early work start times, a compressed work week into 12 hour shifts, and night work.[27,59,66] Shift workers often develop chronic sleep disturbances, leading to reduced sleep quantity and quality.[59] In this population, reduced sleep quantity (4 to 7 hours) as associated with increased health risk outcomes, such as cardiovascular disease, type 2 diabetes, and occupational accidents.[59] Kecklund et al. found a moderate correlation between reductions in sleep and health risk outcomes, but causation was not investigated.[59] When comparing day, night, and rotating shift workers, night and rotating shift workers were found to have greater rates of heart disease.[14] These studies indicate the associated risks with insufficient sleep and lead us to think that collegiate athletes may have adverse outcomes without proper sleep.

Sleep in the Collegiate Student Population

A subgroup of the general population is college student population, and sleep trends in this population should be understood before addressing the collegiate varsity athletics population. The collegiate population faces different challenges than the general population, as college students have infamously irregularly sleep schedules and demonstrate poorer patterns of sleep compared to other healthy adult populations.[7,18] As a result of these irregular sleep schedules and poor patterns of sleep, college students in the United States commonly experience significant levels of sleep deprivation, sleep disturbances, and daytime sleepiness.[18] Over 60% of college students are poor sleepers.[20] Buboltz et al. found that in a sample of 191 undergraduate collegiate students only 11% of participants were found to have consistently good sleep quality.[67]

Class scheduling may cause irregular daytime patterns and appears to play a large role in collegiate sleep trends. After studying a single sample of collegiate students for a two week period during a semester of early class start times and a two week period during a semester of late class start times, it was found that early classes degrade sleep.[31] Reduced sleep quantity was observed as the early class semester led to a mean of 6.92 hours slept was observed, while late classes led to a mean of 7.42 hours slept. [31] Reduced sleep quality was observed through PSQI scores, as early classes showed significantly decreased sleep quality as compared to late classes.[31] One possible explanation for the differences in time slept is sleep chronotype. Personal chronotypes are shown to not change, even during lengthy changes in wake time schedule, such as a semester long change to early classes.[31] Therefore, while early chronotypes have few issues with early classes, late chronotypes cannot adjust. Later classes, however, allow late chronotypes to awake at a more comfortable time while early chronotypes can still wake early. In the assessment of chronotype in 372 university students, Schneider et al. found 4.6% of students to be morning type (awaken early in the morning with a good level of awareness), 55.9% of students to be intermediate type, and 39.5% of students to be evening type (wake up later in the day and prefer a late night bedtime).[68] This distribution may be problematic, as collegiate students often have morning classes. The challenges facing the collegiate population must be considered when assessing the sleep trends of collegiate athletes; these athletes are a subset of the larger collegiate population.

Sleep in the Athletic Population

It is reasonable to suggest that sleep plays an important role in athletics, but there is a lack of research and consensus into the normative sleep needs of athletes.[1,3,8,17] Collegiate varsity athletes will face the same challenges as the remaining college population in addition to any supplementary challenges imposed by athletic participation. It is generally accepted that athletes perform higher physical exertion and experience more situational stressors than the general public. These situation stressors, possibly seen as competition or increased work load in practice, further complicate attempts to define normative sleep in athletics.[2] When preparing for competition, decreased sleep tends to trend with decreased performance.[1] This diminished sleep may be seen as lowered quantity and/or quality.[2] In addition to the link between sleep and performance, there is a link between sleep and recovery.

Sleep is commonly recognized as an important component in athletic recovery.[1–3,5,17] Recovery from the mental and physical demands of high-performance sport is facilitated by sleep.[4] Psychological and physiological well-being are both affected by sleep, with consolidation of new information into memory, restoration of tissue, restoration of immune and endocrine systems, and detoxification occurring during sleep.[8] As previously mentioned, REM and NREM sleep have been linked to multiple recuperative processes.[5,6,21] The recovery-sleep relationship is further supported as SWS, the final stage of NREM sleep, in athletics is analyzed. Increased training volumes have been linked to increased time in SWS the following night, showing a link between sleep and recovery.[21] With evidence supporting the need for sleep in recovery, athletes should be utilizing sleep to the best of their abilities. Because sleep is important in recovery, it can be reasoned that those who exert more and require greater recovery from this exertion may also have different sleep requirements.

Despite its importance for preparation, performance, and recovery, it appears athletes do not obtain optimal sleep.[1–3,12,18,65] Mean sleep of athletes has been reported as 6.68-7.42 hours.[1,2,12,18] Utilizing a study of 628 athletes recruited from 29 division 1 sports, Mah et al. found that athletes reported an average of 7.54 hours sleep on weekdays and 8.4 hours on weekends.[69] Mah et al. also found 39.1% of athletes in this study reported an average total sleep time below 7 hours, and when using team average sleep, 58.6% of team averages were below 7 hours. In a sample of 70 elite athletes with a mean age of 20.3 years, 926 nighttime sleep events were recorded. Of these 926 sleep occurrences, 88% fell below 7 hours in length.[3] Another study found that 46.5% of participants, classified as student athletes based on participation on a university athletic club team, presented with poor sleep quality, as measured using the PSQI (utilizing a poor sleep threshold of 5.5 points).[65] When utilizing the PSQI in a sample of 628 division 1 athletes, Mah et al. found on average athletes are poor sleepers (total sample average PSQI = 5.28, 42.4% of athletes PSQI score >5), and 16.6% of athletes reported "fairly bad" or "very bad" sleep quality.[69] Carter et al. utilized the PSQI in a sample of 121 collegiate athletes, and found 35% of athletes were poor sleepers (PSQI score >5).[70] This study also found 19% of athletes to have excessive daytime sleepiness via the ESS (score >10).[70] In a study by Leeder et al. comparing the athletic population to age and biological sex matched general population members, quantity of sleep was found to be equal, while sleep quality, as determined by wristwatch actigraphy measured sleep efficiency, was significantly decreased in the athletic population.[1] Mah et al. utilized the ESS (Epworth Sleepiness Scale) in a sample of 628 division 1 athletes, and it was found that 51% of athletes reported high levels of daytime sleepiness (scored ≥10 on the ESS).[69] This variability in reports of quantity in the athletic population shows a disagreement as to whether athletes achieve less sleep than the recommended amount, or if athletes are achieving the recommended hours but staying low within this recommended range. It is difficult to truly assess whether athletes are obtaining sufficient sleep, as normal sleep needs in the athletic population are unknown.[1,3,8,17] While 6.5 to 7.5 hours of sleep may arguably be sufficient for athletes, there is no evidence to support this. In addition to the lack of agreement in obtained quantity, there is a lack of research into the quality of sleep obtained by athletes.[1,2] The absence of a standard definition for sleep quality has hindered research into this measure.[43]

Athlete sleep appears to be affected by chronotype, as athletes with evening chronotypes tend to experience more sleep difficulties.[4] As previously mentioned, there exist factors that may prevent individuals from matching their actual sleep schedule to their preferred circadian rhythm. In addition to the previously mentioned school, work, and social commitments, athletes have the additional obstacle of practice and game commitments.[5] It is difficult to understand the sleep needs of athletes due to the lack of guidelines and complicated schedules of athletes.

In evaluating sleep trends in elite athletics, it should be noted that different classifications of athletes reveal different trends. In the assessment of athletes classified as elite, Gupta et al. reports individuals who compete in a team sport setting, such as soccer, have displayed significantly decreased total sleep time when compared to individuals competing alone, such as swimmers.[37] This comparison of team to individual sports should be viewed skeptically, as there is very little research conducted in the team sport setting.[7]

When considering the effects of insufficient sleep in the athletic population, it is important to remember the previously discussed effects of insufficient sleep on the general population. At a minimum, athletes likely experience the same effects of insufficient sleep as the general population. Furthermore, there will be negative effects on performance and recovery. It appears that sleep disturbance influences athletic performance, especially when sleep disturbances occur over a long duration.[17] When sleep deprivation occurs, the immune and endocrine systems are impaired, which then impairs recovery.[17] By preventing sleep disorders, or improving upon sleep disorders that may already be present, competitive abilities and performance may be increased and athletic conditioning maintained.[65] Therefore, maximizing sleep may be one method to enhance performance.[17]

When investigating the effect of sleep on performance, it is difficult to isolate specific, individual motor skills that comprise performance.[33] This provides a challenge in assessing the complex technical skills of athletic performance. For this reason, studies assessing the effect of sleep on performance often use common physical assessment tests, such as the Wingate test or 1 rep max, to assess performance. There are few studies investigating the effects of restricting athletes sleep; comparing study to study, there are conflicting results.[7,8] It is difficult to understand the extent and mechanisms of the effect of sleep loss on exercise performance due to these conflicting findings.[7] Furthermore, when reviewing studies, attention must be paid to whether the study utilized sleep deprivation, defined as extreme and prolonged cases of sleep loss, or sleep restriction, defined as a partially disturbed sleep-wake cycle.[7] Sleep deprivation is a state of 0 hours slept per night, while sleep restriction may be 4-6 hours per night.[13] A majority of studies utilize sleep deprivation, but sleep restriction is more commonly experienced by athletes.[7] It has been reported short term sleep deprivation is not detrimental in muscle strength testing or anaerobic testing.[33] Despite finding no changes in strength and anaerobic testing, endurance performance testing is seen to be hampered by sleep deprivation.[33] The relationship between performance and sleep is further complicated by the association between perception of performance and sleep. Reduced sleep quantity and quality have been associated with increased pre-training fatigue levels and general daytime fatigue.[3,37] This increased pre-training fatigue may affect an individual's perception of effort.[33]

Investigating the effects of insufficient sleep in an athletic population may be difficult due to a lack of athletes available to participate in studies.[7] Therefore, studies into the effects of increasing sleep of athletes have been used as an alternative method to investigate sleep's relationship with athletic performance. Mah et al. found that increasing mean time slept by athletes also led to increased performance, as measured by sprint time and basketball free throw and three point shooting accuracy.[12] Schwart et al. found increasing time asleep decreased feelings of sleepiness, increased serving accuracy, and increased performance in collegiate tennis players.[18] If increasing time slept will increase performance, then it is reasonable to believe that decreasing sleep will lead to decreased performance. Interestingly, 57.1%[8] and 46.4%[2] of athletes who report decreased sleep before competitions also report no perceived effects of this decreased sleep. It is hard to assess the negative impacts of insufficient sleep in athletics due to the complexity of sleep, lack of research and research participants, and the variability of individual sleep requirements.[7]

The Relationship Between Practice and Sleep

In the collegiate sports setting, practices of different teams will occur at different times of the day. These times can be divided into morning, midday, and evening. There are many reasons a team may choose to practice in the morning rather than the night, such as academic schedule conflicts or sharing the practice facility with another team.

With teams practicing at multiple different times of the day, the effects of practice time on sleep must be explored.

Morning Practice

Early morning training results in decreased sleep and increased pre-training fatigue levels.[3] In a study utilizing student athletes, classified as such based on participation on a university club athletics team, participants with morning practices 4-7 days per week had significantly higher odds of developing sleep disorders, as determined by the PSQI.[65] Mah et al. found that 71% of the division 1 athletics teams reporting an average sleep time less than 7 hours also reported an average wake time before 7:30 AM.[69] In this study, it was also found that 5 teams reporting high daytime sleepiness (team average ESS score ≥10) also reported an average waketime of 7:00 AM.[69] It appears that athletes attempt to self-adjust their bedtimes to be earlier to allot ample sleep time, but they are unsuccessful in meeting quantity goals.[3] While athletes attempt to prep for early morning practices by going to bed sooner in the evening, they are still losing sleep. Bedtimes can be moved to sufficiently earlier times, but sleep onset is not occurring at a sufficiently earlier time.[3] Therefore, the occurrence of sleep latency is preventing athletes from adequately increasing sleep quantity despite going to bed earlier. In addition, moving bedtime to an early time is not always possible. Lifestyle commitments, such as social obligations or homework, and circadian rhythm limitations make it difficult to effectively move bedtime to earlier times.[3] An athlete whose circadian rhythm prefers late bed time may struggle to fall asleep. If sleep is lost prior to early morning practices, then motivation at practice may be decreased.[6] This motivation factor suggests that sleep affects more than just recovery; sleep may also affect practice quality.

Evening Practice

Late evening practice creates obstacles that may decrease sleep quantity and quality in the athletic population. Following late night competitions, 52.5% of athletes experience poor sleep.[2] This poor sleep may be a result of delayed bedtime, soreness following competition, or other factors. Late night training sessions push bedtime back to later in the night, leading to insufficient sleep.[6] If practice does not end until 9:00 PM, bedtime will not occur until later in the evening. Even if practice ends at 7:00 PM, bedtime may be delayed as practice is often followed by an athlete needing to eat dinner and complete homework before going to bed. Anecdotal evidence suggests sleep will decrease following night athletic performances, as athletes tend to report increased sleep disturbances following night games.[6] There is little research into this anecdotal finding. Soreness or injuries resulting from late night practices may also cause decreases in sleep, as pain is associated with increased sleep disturbances.[6] Increased wakening events during sleep following an evening practice may occur due to hyperhydration.[17] During and following practice, athletes should have an increased fluid intake to maintain a hydrated state. This increased fluid intake then leads to increased need for urination the following night. In addition to these obstacles, if an early wake time is required by the student-athlete's schedule, possibly an early class, the athlete will not be able to compensate for later time to bed with a delayed wake time. It appears that evening practices are associated with negative outcomes, and further investigation into this would be beneficial for coaches and athletes.

Other Factors Negatively Affecting Sleep in Athletics

Time Zone

Travel across multiple time zones commonly leads to jet lag, or a lack of synchronization between an individual's internal clock and true local time.[33] When athletes have a competition in a different time zone, they often travel to this time zone a few days before competition to allow circadian rhythm entrainment.[33] Internal clock synchronization to time zone changes, also known as entrainment, is a slow process that takes at least 1 day per time zone crossed to occur.[27,33] Direction of time zone change (eastward travel or westward travel) may play a role in the effect of the change.[37] When traveling westward across time zones, circadian adjustment occurs more quickly than eastward time zone travel.[33] An example of problematic eastward travel is an athlete traveling from the west coast of the US to the east coast of the US for an 8 PM EST game. If this athlete is unable to entrain their circadian rhythm before the game, then the 8 PM EST game may feel like a 11 PM game to the athlete, possibly leaving the athlete tired at game time. Time zone change should be considered when creating athletics schedules involving travel to prevent problematic time zone travel. It may be beneficial to travel at an earlier date to allot athletes more time in the new time zone for entrainment before competition.

Short-Haul Air Travel

Long distance travel does not always require time zone changes. Therefore, jet lag cannot occur in these instances. Travel within one time zone via plane may affect match outcome, as short-haul air travel occurs in this instance.[71] Short-haul air travel acutely increases perceptual fatigue.[71] It should be noted there is very little research into the effects of short-haul air travel on physical performance, technical and tactical performance indications, and match outcome.[71] Athletes may experience sleep disturbances resulting in reductions in mood, acute fatigue, and difficulty initiating sleep.[6] Other effects of travel may include dehydration and lack of motivation, which in turn will affect training session quality.[6] When short-haul air travel occurs, athletes and coaches should be aware of the possible negative outcomes.

Competition

Decreased sleep the night before competition is repeatedly reported in interviews with athletes.[2,7,8,15] Studies into this phenomena have returned consistent results, with 64%[2] and 65.8%[8] of athletes reporting decreased sleep the night before competition. These studies assessed athletes' beliefs regarding their sleep but did not objectively assess for true hours slept. Apprehension the night before competition is a probable driving factor in sleep loss.[2,8,15] Problems falling asleep was the most commonly reported challenge to sleep the night before competition, as it was reported in 79.7%[8] and 82.1%[2] of athletes who reported experiencing poor sleep. Commonly reported reasons for trouble falling asleep were thoughts about competition and nervousness.[2,8] Thoughts about competition and anxiety are examples of internal factors causing decreased sleep, as opposed to sleeping in a new environment or sleeping in a noisy environment being examples of external factors. These studies found that internal factors were the most commonly reported reasons for decreased sleep.[2,8] It may be worth attempting to classify an athlete's sleep obstacles as internal or external, as this allows a better understanding of the obstacle and how to best address the sleep loss.

Congested competition schedules have been associated with increased injury risk and a potential for decreased sleep quantity and quality.[6] Competition may entail increased workload for athletes with high game time minutes. High workload volumes have been associated with greater sleep disturbances.[6] Therefore, it can be inferred that athletes experiencing increased workload may have resulting increases in sleep disturbances. Overall, there is a lack of research regarding athlete sleep the night before competition.[8]

Factors that may Positively Influence Sleep in Athletics

Napping

When night time sleep is lacking, athletes commonly utilize day time naps to compensate for the lost sleep.[37] This use of napping to increase total sleep time per day suggests sleep duration is important for athletes.[33] Athletes commonly employ napping, but little information is known about the effects of naps.[15] In one sample, 27% of the 70 athletes in the study reported napping with an average nap time of 49.3 minutes.[3] When utilizing 628 athletes participating in division 1 athletics, Mah et al. found that 80% of athletes napped at least once per week, with at least 11% of athletes napping before games or competitions.[69] When a 30 minute post lunch nap was required, Waterhouse et al. observed that sprint time and memory errors both significantly decreased, meaning it took athletes less time to complete the same distance sprint and less errors occurred during memory testing.[15] Mah et al. reports napping following decreased sleep improves reaction time (seen as a decrease in time taken to react), sprint times (seen as decrease in time needed to sprint the preset distance), and vigilance performance tasks.[12] Overall, it has been observed that napping results in improved performance outcomes in athletes.

If napping is to be employed by athletes, care must be taken to prevent this napping from negatively affecting patterns of night time sleep.[6] Excessive daytime napping may lead an athlete to change night time sleep in a undesirable way, such as pushing back bedtime due to decreased sleepiness after napping. It should also be noted that napping 4 or more times per day is associated with decreased sleep quality.[39] Reasoning behind this may be that poor sleep quality is causing increased daytime sleepiness, which then causes an increased desire to nap multiple times. While napping may be beneficial to athletes, care should be taken to prevent napping from negatively affecting nighttime sleep.

Sleep Extension

Sleep extension is the practice of purposefully increasing the number of hours spent sleeping in one day. In one sleep extension study, athletes were instructed to obtain a goal of 10 hours of sleep per night, then performance measures and subjective mood questionnaires were used on a daily and weekly basis.[12] It was found that total daily sleep time increased through the study, sprint time decreased, basketball free throw and three point shooting accuracy improved, and mood improved as compared to a previously recorded 2 to 4 week baseline.[12] These athletes were in-season collegiate varsity basketball players, and it is commonly assumed that athletes increase in tiredness and fatigue as the season progresses.[12] However, this trend was not seen in athletes participating in the sleep extension program, suggesting that sleep extension fights in-season exhaustion.[12] These collegiate basketball players subjectively reported quicker physical recovery and improved weight training and conditioning during the sleep extension program. Another study found sleep extension to decrease feelings of sleepiness, improve serving accuracy, and improve performance in collegiate tennis players.[18] The observation of sleep extension increasing performance suggests sleep duration plays an important role for athletes.[33]

Rationale for Study

Sleep is an essential component of good health, with an increased importance regarding performance and recovery in athletics.[1–3] Performance and recovery are impaired by decreased sleep.[1,4] Diminished performance may be the deciding factor in winning or losing a competition.[15] Therefore, circumstances leading to decreased sleep should be avoided. Time of day training and competitions occur is believed to affect sleep.[2,3] Both morning and night athletic events have shown negative effects on sleep. Meanwhile, training at a time encouraging good sleep will promote ideal preparation and recovery. Hence, an understanding of the effects of training time on sleep is needed to produce an ideal schedule, which in turn promotes performance and recovery. Coaches, strength and conditioning staff, and medical personnel would benefit from an understanding of the relationship between sleep and training schedule.

There is a lack of research into sleep in the athletic population.[7] Of the studies found investigating sleep's affects in an athletic population, small sample sizes and individual competition sport participants are commonly utilized and power is often not reported or reported power is low.[7,33] The normal sleep needs of athletes are unknown.[1,3,8] The absence of a standard definition for sleep quality hindered research into this measure.[43] No studies were found comparing the differences in sleep quantity and quality between multiple practice times. Current research shows restrictions due to the multitude of variables affecting sleep in athletics, limitations of research methodology, and the small sample sizes frequently used in this research.[5] Studies performed can also be difficult to compare, as measures of quality are inconsistent. Minimal research on sleep in elite athletes has been conducted, causing a lack of scientific information about sleep requirements and characteristics in elite athletes.[17]

CHAPTER 3

METHODS

Design

A stratified cohort study design was used by identifying groups of different exposures (practice times). Subject stratification was based on sport participation, with each included sport representing a different practice time group (morning, midday, evening). All participants completed an entrance questionnaire to determine eligibility for inclusion (Appendix 1). Following inclusion in the study, participants were asked to complete both a daily questionnaire and a weekly questionnaire. The daily questionnaire assessed perceived sleep quantity and participation in practice for four weeks (see Appendix 2). The weekly questionnaire assessed sleep quality using the Patient-Reported Outcomes Measurement System (PROMIS) Sleep Disturbance short form (see Appendix 3). Following 4 weeks of data collection, participants were asked to complete an exit questionnaire regarding social/behavioral habits (see Appendix 4).

Participants

We recruited a convenience sample of athletes between 18 and 26 years of age from three athletic teams at a division 1 institution (combination of varsity and junior varsity) the University of North Carolina at Chapel Hill.

Inclusion criteria were as follows:

- biological sex male

- aged 18 to 26 years, a member of one of the three predetermined sports teams
- participated in daily practices with the athletic team to which they belong

Exclusion criteria were as follows:

- participants who self-reported the prior diagnosis of sleep disorder in the entrance questionnaire
- participants who self-reported the prior diagnosis of mood disorder in the entrance questionnaire
- participants with a high risk of sleep apnea as determined by the STOP-BANG Questionnaire for sleep apnea (Yes answer for any 5 to 8 questions, Yes answer for 2 or more STOP questions and biological sex male, Yes answer for 2 or more STOP questions and BMI greater than 35 kg/m^2, or Yes answer for 2 or more STOP questions and Yes answer for neck circumference)[58]
- participants who reported not participating in ≥50% of practice sessions during the four-week data collection period
- participants who completed the daily questionnaire <75% of days during the four-week data collection period

No subject incentives were provided for participation in this study. Participants were provided written informed consent and the study methods and procedures were reviewed by the Institutional Review Board of UNC-Chapel Hill.

Procedures

Athletes were targeted for recruitment based on a priori understanding of their practice schedules (Men's Lacrosse 8 AM, Baseball 1 PM, and JV Basketball 6 PM practice start times). Informational consent forms were handed out during a preseason team meeting of the varsity men's lacrosse, varsity baseball, and junior varsity basketball teams. Those who chose to participate completed the consent form and the entry questionnaire (see Appendix 1). This was given as a paper copy.

Participants were asked to fill out the sleep quantity and practice participation questionnaire (see Appendix 2) daily, beginning the first Monday following recruitment and ending following the completion of data collection. Data were collected from four continuous weeks of pre-season practices during the corresponding preseason period for each sport (Fall semester for the JV Basketball team, and Spring semester for the Varsity Lacrosse and Baseball teams). The four weeks chosen were those in which the team is subject to NCAA mandated 20-hour weeks. This four-week period of 20-hour practice weeks did not occur at the same time of year for all three teams, therefore the data was not collected during the same four-week period for every team.

The daily questionnaire was conducted using the Qualtrics online survey tool (see Appendix 2), which could be accessed by participants via smart phone app or computer. The questionnaire was delivered daily to participants through email (student email account), with each participant receiving an individualized link in this email. Participants were instructed to take this questionnaire within one hour of awakening using only their individualized link; not to access the questionnaire from another participant's emailed link. A reminder alert was sent daily via email at 10 AM from Qualtrics to all participants who had not yet completed the questionnaire. A second reminder was sent to all participants via their team's preferred mode of communication (Teamworks app, group messaging, etc.) at 2 PM. The questionnaire took approximately 5 minutes per session to complete.

Participants were asked to fill out the PROMIS Sleep Disturbance short form (see Appendix 3) weekly, beginning the first Saturday of the data collection period. Data were collected from the same four continuous weeks of 20-hour practices as the daily questionnaire. The weekly questionnaire was conducted using the Qualtrics online survey tool (see Appendix 3), which could be accessed by participants via smart phone app or computer. A reminder alert was sent on Saturday via email at 12 PM from Qualtrics to all participants who had not yet completed the questionnaire. A second reminder was sent to all participants via their team's preferred mode of communication (Teamworks app, group messaging, etc.) at 2 PM on Saturday. The questionnaire took approximately 5 minutes per session to complete.

Following 4 weeks of data collection, participants were asked to complete an exit questionnaire regarding social/behavioral habits (see Appendix 4). This questionnaire was conducted using the Qualtrics online survey tool (see Appendix 4), which could be accessed by participants via smart phone app or computer. A reminder alert was sent at 12 PM from Qualtrics to all participants who had not yet completed the questionnaire. A second reminder was sent to all participants via their team's preferred mode of communication (Teamworks app, group messaging, etc.) at 2 PM on Saturday. The questionnaire took approximately 5 minutes per session to complete.

Measures

To assess sleep quantity and practice participation, participants were asked to complete a questionnaire everyday within 1 hour of waking up. The first two questions were used to assess nighttime sleep quantity, asking the participant to report bedtime the night before and wake time the day of questionnaire completion. Questions 4 and 5 assessed for naps taken by the participant the previous day. Question 5 assessed naptime sleep quantity, asking participants to report total time spent napping the day before. Nighttime sleep quantity was used to calculate total sleep quantity for each participant. The 3rd question was used to assess subjective sleep quality. The remaining 2 questions were used to assess participation in practice. The specifics of the sleep quantity and practice participation questionnaire can be found in Appendix 2.

To assess sleep quality, participants were asked to complete the PROMIS Sleep Disturbance short form weekly (see Appendix 3). The PROMIS Sleep Disturbance short form questionnaire is an 8-item questionnaire developed from the original long forms.[53] The short form has been found to correlate strongly with the original long form as well as showing low standard error.[53] The PROMIS Sleep Disturbance short form questionnaire has been found to have construct validity, reliability, and convergent validity (when compared to the PSQI and ESS).[53]

Data Management

Subject characteristic data were collected from team roster information. Items collected include number of athletes listed as members of the team and athlete age. Subject use of sleep aids was collected from the entrance and exit questionnaires. Subject social/behavioral habits, such as drug and alcohol use, were collected from the exit questionnaire (see Appendix 4).

Each participant's daily questionnaire answers to the quantity and practice participation questionnaire were automatically linked to that participant via Qualtrics. Answers to the questionnaire were exported into an excel sheet. In excel, this was organized with columns representing subject ID, cohort assignment, date, reported time to bed, reported wake time, total sleep quantity, occurrence of nap, total time napping, subjective sleep quality, occurrence of practice, and participation in practice. There were multiple rows per subject, with each row containing data from one day of collection. Total sleep quantity was calculated by finding the difference between time to bed and time awake. Practice participation data was used to exclude participants based on not participating in ≥50% practice sessions. Participants who answered "no" to the question "Did you participate in this practice?" ≥50% of days that this question is answered (this question will only be asked following a "yes" answer to the question "Was there a team practice yesterday?") were excluded from data analysis.

Each participant's weekly PROMIS Sleep Disturbance short form answers were automatically linked to that participant via Qualtrics. Composite PROMIS sleep Distribution short form scores were automatically calculated though Qualtrics. Answers to the questionnaire and composite scores were exported into an excel sheet. In excel, this was organized with columns representing subject ID, cohort assignment, date, composite score, and each question. Subject ID will match subject ID assignment for the daily questionnaire. There were multiple rows per subject, with each row containing data from one day of collection.

Statistical Analysis

Participant characteristics were examined. Characteristics of interest included daily practices times of groups, number of participants per group, subject age, subject weight, subject height, reported use of sleep aids, and reported social/behavioral habits. The number of participants excluded based on each exclusion criteria was examined. General sleep quantity (in hours slept) and sleep quality (PROMIS Sleep Disturbance short form T score) characteristics were examined in the pooled sample, as well within each study group. Distributional properties of the measured variables were assessed. Group differences in sleep quantity were examined using a repeated measures ANOVA (RMANOVA), with a primary group factor of interest (practice times). Differential change (between groups) in sleep quantity over the 4-week period were tested using the RMANOVA. Group differences in sleep quality were examined using a repeated measures ANOVA, with a primary group factor of interest (practice times). Differential changes (between groups) in sleep quality over the 4-week period were tested using the RMANOVA. Statistically significant results observed in the omnibus test were evaluated further using post-hoc tests. Statistical significance was evaluated at the 0.05 level, and all analysis was conducted using Statistical Package for the Social Sciences (SPSS, Version 24).

CHAPTER 4

RESULTS

The purpose of this study was to evaluate the differences in sleep quantity and sleep quality among collegiate athletes who practice at different times of the day (morning, midday, and evening).

Subject Characteristics

A total of 69 subjects (morning cohort: n= 21; midday cohort: n=33; evening cohort: n=15) consented for this study. Based on the inclusion criteria,7 subjects were then excluded. There were 3 exclusions based on high risk of obstructive sleep apnea as decided using the STOP-BANG questionnaire, 1 exclusion due to a reported previous diagnosis of mood disorder, and 1 exclusion due to reported previous diagnosis of sleep disorder. Of the remaining 62 subjects, 9 subjects opted out of the study via email (8 morning and 1 midday). The remaining 53 subjects received the daily questionnaire every day for the 27-day collection period and received the weekly questionnaire 4 times (same day of the week) within the 27-day collection period.

Of the remaining 53 subjects, 29 subjects (6 morning, 20 midday, and 3 evening) were excluded based on a priori criteria for the requisite number of daily responses (75% of the total number of days). This left a total of 24 subjects (morning cohort: n= 7; midday cohort: n=6; evening cohort: n=11, as seen in Table 1).

Table 1: Demographics				
Variable	**Group 1: Morning (n= 7)**	**Group 2: Midday (n= 6)**	**Group 3: Evening (n= 11)**	**Total (n= 24)**
Age (Mean, SD)	19.71 (.756)	20.17 (1.835)	18.82 (.603)	19.42 (1.176)
Height, Inches (Mean, SD)	71.57 (2.573)	73.67 (.816)	74.91 (3.33)	73.62 (2.961)
Weight, Pounds (Mean, SD)	187.57 (16.622)	190.67 (36.120)	185.09 (22.029)	187.21 (23.916)
Sleep Aid Use Before (n, %)	3 (42.86%)	0	0	3 (12.5%)
Sleep Aid Use During (n, %)	2 (28.57%)	0	0	2 (8.33%)
Alcohol Use During (n, %)	4 (57.14%)	1 (16.66%)	5 (45.45%)	10 (41.67%)

The average age of all subjects was 19.42 years (±1.176) (see Table 1 for group-stratified ages). Average height in inches of the total population is 73.62 ±2.961 (morning 71.57 ±2.573, midday 73.67 ±0.816, evening 74.91 ±3.33). Average weight in pounds of the total population is 187.21 ±23.916 (morning 187.57 ±16.622, midday 190.67 ±36.120, evening 185.09 ±22.029).

Lifetime use of sleep aide was reported by 3 subjects total (all morning cohort), and 2 of these subjects (all morning cohort) reported the use of a sleep aid during the collection period. No other subjects reported sleep aid use during the collection period Lifetime use of a sleep aid was reported as 1-2 nights per week by 1 subject, 3-5 nights per week by 1 subject, and greater than 5 nights per week by 1 subject. The 2 subjects who reported using sleep aids during the study period used sleep aids 1-2 nights/week and are the same subjects as 2 of the 3 subjects reporting use of a sleep aid before the collection period. Ten subjects total (4 morning, 1 midday, and 5 evening) reported alcohol consumption during the collection period. All participants who reported alcohol consumption during the collection period reported consuming alcohol 1-2 times per week.

Practice frequencies and participation patterns are presented in Table 2. There were 55 total team practices that occurred throughout the collection period, with 20 morning practices, 21 midday practices, and 14 evening practices. The average number of practices attended by subjects is 19 ±3 in the morning, 19 ±3 in the midday, and 14 ±3 in the evening.

Table 2: Team Practice Information

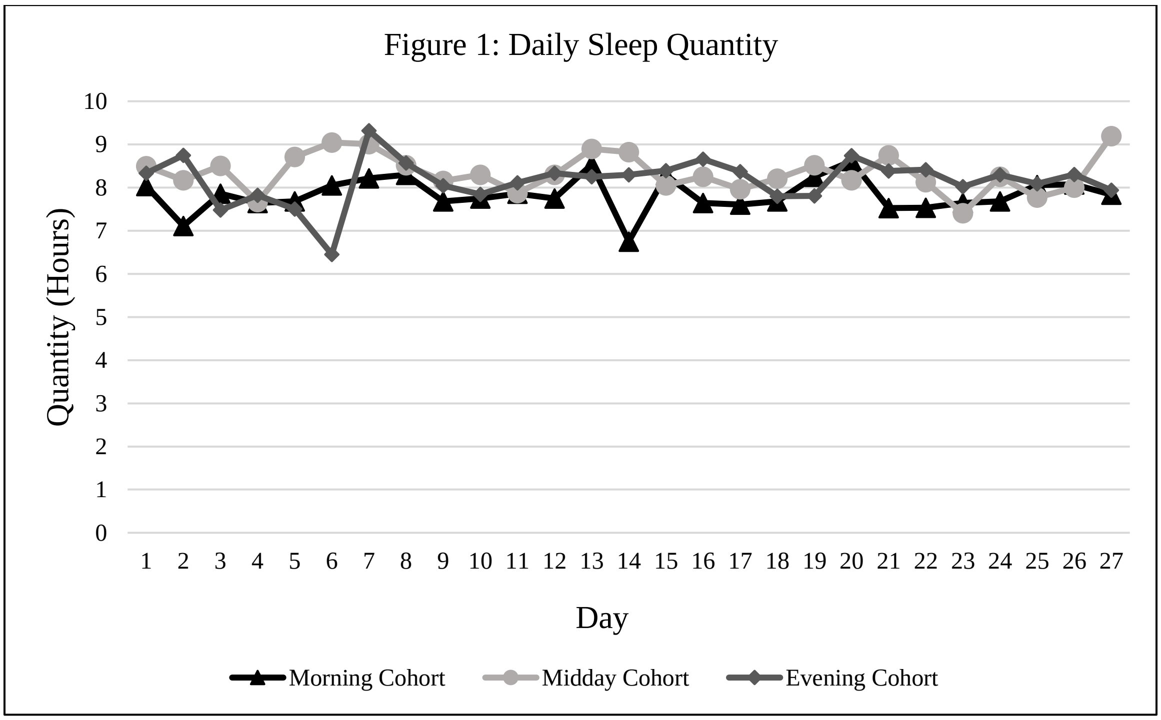
Variable	**Morning Cohort**	**Midday Cohort**	**Evening Cohort**
Total Number Practices During Collection Period	20	21	14
Average number of practices attended by participants	19 (3)	19 (3)	14 (3)

Sleep Quantity

Sleep quantity was measured as average hours slept per night per subject. On average, study subjects reporting sleeping 8.14 hours per night. No differences in sleep quantity between cohorts were observed upon visual inspection of Figure 1. There were no significant differences in average hours slept between the 3 cohorts (morning: 7.84 hours, midday: 8.34 hours, evening: 8.15 hours, see Table 3) as determined by the results of the repeated measures ANOVA ($F(2,21) = 1.045$, $p = .369$). Trajectories of average sleep quantity are presented in Figure 1. Daily average sleep quantity per player was then distilled into weekly average sleep quantity per player, leaving 4 weekly sleep quantity measurements per player. When utilizing a repeated measures ANOVA to compare weekly average sleep quantity per player per cohort, no significant differences were found (F (2,21) = 1.150, p = .336).

Table 3: Sleep-Related Measurements

Variable	**Morning Cohort**	**Midday Cohort**	**Evening Cohort**
Average Daily Sleep Quantity per Player (mean, SD)	7.84 (.44)	8.34 (.52)	8.15 (.77)
Average Daily Sleep Quality Proportion per Player:			
Very Bad (mean)	01.79%	00.72%	00.48%
Bad (mean)	08.36%	04.39%	06.84%
Fair (mean)	26.15%	17.50%	26.34%
Good (mean)	16.22%	20.30%	20.68%
Very Good (mean)	47.49%	57.09%	45.66%
Occurrence of Frequent Napper (over 30% of days) (n, %)	2 (28.57%)	0	1 (9.09%)



Sleep Quality

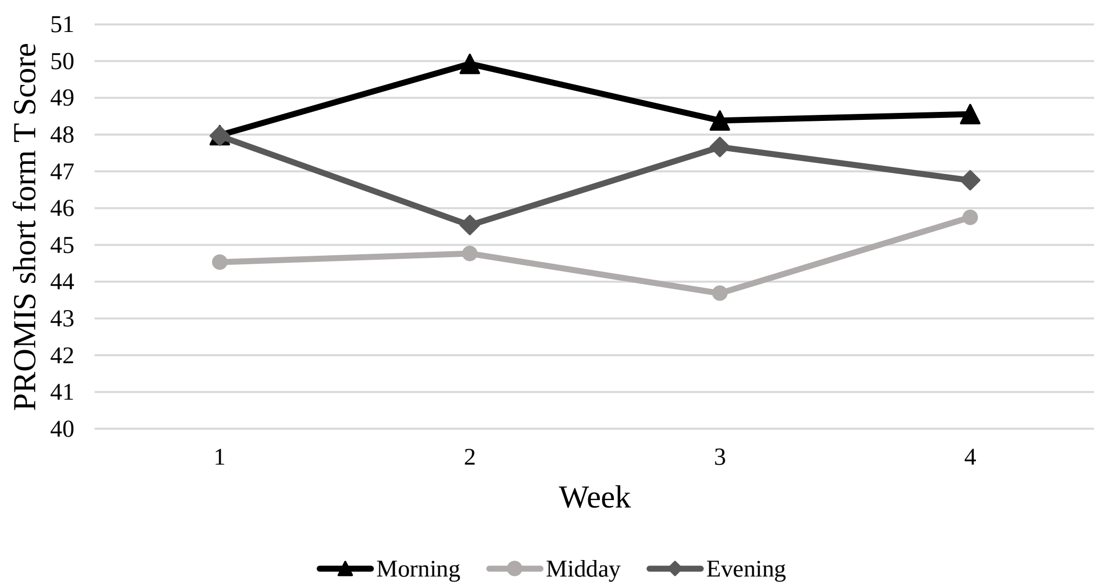
The mean daily sleep quality per player per cohort is described as a proportion in Table 3. The majority of participants generally reported good and very good sleep quality throughout the collection period. Weekly sleep quality assessed through the PROMIS sleep disturbance short form is in Table 4. Trajectories of sleep quality scores (determined using the PROMIS sleep disturbance short form) are presented in Figure 2.

Table 4: Weekly PROMIS

Variable	Week 1	Week 2	Week 3	Week 4
Morning cohort	47.99 (9.29)	49.93 (6.43)	48.39 (7.53)	48.56 (7.21)
Midday Cohort	44.53 (6.32)	44.77 (7.24)	43.68 (6.12)	45.75 (4.68)
Evening Cohort	47.96 (7.82)	45.54 (7.96)	47.66 (7.15)	46.75 (9.18)

Higher T Score is indicative of increased sleep disturbance. T score 50 is the population mean.

Figure 2: Weekly Sleep Quality



No differences in sleep quality between cohorts were observed upon visual inspection of Figure 2. No group differences in weekly sleep quality were observed as determined by the results of the repeated measures ANOVA ($F(2,21) = 0.534$, $p = .594$).

Supplemental Analysis

Supplemental analysis was conducted utilizing nonparametric testing, as our data set did not fulfill the assumptions of RMANOVA testing. Further supplemental analysis was run utilizing reported sleep quantity for days 1-12. Upon visual inspection of the collected data, it was observed that subjects completed the daily questionnaire more consistently during the first 12 days of the collection period. Therefore, when utilizing days 1-12 and a daily questionnaire completion rate of ≥ 75%, a larger subject sample was retained for analysis.

Separate Kruskal-Wallis tests (week 1, week 2, week 3, and week 4) using the same sample group were used to compare weekly reported mean sleep quantity between groups. No significant group differences in weekly average hours slept between the 3 groups were observed, during week 1 ($\chi^2(2) = 2.533$, $p = .282$), week 2 ($\chi^2(2) = 2.957$, $p = .228$), week 3 ($\chi^2(2) = 3.614$, $p = .164$), week 4 ($\chi^2(2) = 1.538$, $p = .464$).

Separate Kruskal-Wallis tests (week 1, week 2, week 3, and week 4) were then run using the same sample group to compare weekly reported mean sleep quality between groups. No significant group differences in weekly sleep quality between the 3 groups were observed, during week 1 ($\chi^2(2) = .557$, $p = .757$), week 2 ($\chi^2(2) = 1.624$, $p = .444$), week 3 ($\chi^2(2) = 1.375$, $p = .503$), and week 4 ($\chi^2(2) = 0.370$, $p = .831$).

In addition to the 27-day sleep quantity assessment, mean sleep quantity per player from day 1 to day 12 was assessed. When using days 1 through 12 with the exclusion criteria of 75% completion rate, 31 subjects remain (10 morning, 9 midday, 12 evening). There were no significant differences in average hours slept between the 3 cohorts, and this was supported by the results of the repeated measures ANOVA ($F(2,28) = 2.462$, $p = .104$). To compare group differences in average hours slept between days 1-12, the Kruskal-Wallis test was then run. We observed no group differences in average hours slept between days 1-12 ($\chi^2(2) = 4.938$, $p = .085$).

CHAPTER 5

DISCUSSION

In this study, we observed insufficient evidence to suggest that sleep quantity and sleep quality varied in collegiate athletes, by practice time. Due to the lack of research into sleep in the athletic population, there are no other current studies comparing the sleep of athletes across three different practice times.[7]

It has been previously reported that average sleep of athletes is 6.68-7.42 hours.[1,12,18,41] In this study, average sleep was found to be higher than previous research, with the morning cohort reporting 7.84, midday reporting 8.34, and evening reporting 8.15 hours daily sleep quantity per player. The higher sleep quantity reported in this study may be more representative of the division 1 male collegiate athletic population, as previously reported averages were found using samples of Olympic athletes,[1] division 1 male collegiate basketball players,[12] division 3 male and female collegiate tennis players,[18] and elite Australian athletes.[41] The utilization of a collegiate athletic population in this study has increased relevance when comparing our results to those found using elite and professional athletes as collegiate athletes have the additional responsibility of academia. In addition to practice scheduling, class scheduling, homework, and studying may affect sleep in collegiate athletes. Alternatively, the higher sleep quantity reported in this study may be misleading: all results in this study should be assessed conservatively due to the limited sample sizes. It is possible that the subjects excluded based on lack of questionnaire completion were reporting significantly lower sleep quantity. If subjects were obtaining low sleep quantity regularly, then they may have stopped completing the questionnaire due to morning fatigue. Perhaps participants obtaining significantly lower sleep quantity stopped completing the questionnaire to not be reminded of their poor sleep. Upon visual observation, the sleep of subjects excluded from this study did appear to be decreased as compared to subjects who were retained. Particularly in the morning cohort, there were observations of subjects reporting 5 or fewer hours of sleep per night, but these subjects were excluded due to poor completion rate on the daily questionnaire. Leeder et al. reports the athletic population achieves the same quantity sleep as the general population.[1] Ohayon et al. states about 75% of participants derived from the general population in 15 U.S. states in their study reported sleeping between 6 and 8 hours per day.[38] The sleep quantity reported in this study falls within this 6 to 8 hours, and therefore the athletes who participated in this study do not appear to have different sleep quantity when compared to the general population. However, comparison of the collegiate athlete to the general population is not the purpose of this study; no data was collected to support this comparison. Furthermore, the National Sleep Foundation recommends 7 to 9 hours of sleep per night.[9] It appears the athletes in this study did acquire the recommended sleep quantity.

It has been reported that morning practice will decrease sleep while increasing pre-training fatigue.[3] It has been previously reported that student athletes with 4-7 morning practices per week have a significantly higher likelihood of developing sleep disorders.[65] This disordered sleep will cause decreased sleep as well as increasing daytime fatigue. In looking at the results of our study, decreased sleep was not found in the morning cohort as compared to the midday and evening cohorts. In a study by Mah et al., it is suggested that early morning waketimes relate to decreased sleep quantity as an average waketime of 7:30 AM is reported by 71% of the teams in this study reporting an average team sleep quantity of less than 7 hours per night.[69] The morning cohort in this study did not reflect this, as this team's average sleep quantity was 7.84 hours per night. Sleep quality was also found to not be significantly different between the groups, suggesting that the morning cohort did not feel increased exhaustion as compared to the other two cohorts. Juliff et al. reports evening competitions lead to 52.5% of athletes experiencing poor sleep.[41] In this study, the evening cohort did not report significant differences in sleep quantity or sleep quality, suggesting they did not experience poor sleep as compared to the other two cohorts. When comparing the Juliff et al. study to this study, it is important to note that Juliff et al. examined evening competition while we examined evening practice. While we did not find significant differences in sleep quantity and quality between different practice times, reported sleep quality is somewhat lower in the morning cohort. The midday cohort reported the highest sleep quality. Due to the lack of research regarding midday practices, it is hard to assess if our data was trending in a predictable way or if this higher sleep quality is unprecedented.

It is difficult to compare the sleep quality found in this study to other research. Sleep quality has no clear definition.[7,37,39,43] Measurement of sleep quality differs greatly between different studies. Mah et al. utilized the PSQI to assess sleep quality among 628 division 1 athletes.[69] When using the PSQI, 42.4% of athletes were classified as poor sleepers (PSQI score >5), and 16.6% of athletes reported "fairly bad" or "very bad" sleep quality.[69] Carter et al. utilized the PSQI as well, and this study found 35% of collegiate athletes are poor sleepers (PSQI score >5).[70] The majority of daily sleep quality reports in this study were “good” and “very good.” The PROMIS sleep disturbance short form was used in this study, and sleep quality was not found to be insufficient. A T score of 50 on the PROMIS sleep disturbance is the general population mean, with increasing T scores indicating increased sleep disturbance.[55] Weekly average sleep quality T scores remained below 50 in this study, indicating within normal limits sleep disturbance as compared to the general population. Sleep quality in this study was measured with different tools than the Mah et al. and Cart et al. studies, therefore sleep quality comparison is limited. It does appear, however, that reported sleep quality in this study is different than that of the Mah et al. and Carter et al. studies. This may, again, be due to the limited sample size of this study. In our study, athletes reported sleep quality over the course of 4 weeks of practice which may have allowed acclimation to their schedules. Athletes may have become accustomed to a lower level of sleep quality and felt that it was not inadequate.

Implications

Due to the relationship between sleep and athletic performance and recovery, creating an athletic schedule that allows good sleep is important.[1,3,4,41] This study found no significant differences in practice time and reported sleep quantity or in practice time and reported sleep quality. This information may be used to schedule athletic events, such as practices, strength training, and games. In utilizing this study to affect athletic scheduling, it appears scheduling in the morning, midday, or evening has no significant effect on the sleep quantity and quality of athletes.

Limitations

When examining these results, it is important to consider the inherent limitations of this study. The first limitation was in the teams available for use in this study. It was decided to use three teams of the same biological sex, therefore men's sports teams were chosen to fulfill the use of a morning, midday, and evening cohort. There are no female teams practicing consistently in the morning or midday with only men's Lacrosse and men's JV Basketball utilizing these times respectively. Female athletes are not represented in this study.

Lack of participation greatly limited this study. The small JV Basketball team and exclusion criteria (specifically lack of questionnaire completion) led subject pools. When recruiting subjects, a goal of 20 subjects per cohort was set to supply the statistical tests with the requisite power to detect differences. It was impossible to have 20 subjects in the evening cohort due to small team size. Lack of questionnaire completion led to many exclusions. The morning and midday teams did not have 20 subjects due to exclusions. Due to small sample size, this study is likely underpowered, limiting the ability to detect differences between groups. This lack of power was demonstrated when supplemental analysis was performed using average daily sleep quantity for days 1-12. Utilizing the required 75% completion rate on the daily questionnaire we retained 31 subjects, as opposed to the 24 subjects retained in the 4-week analysis. When analyzing days 1-12 average daily sleep quantity, our results trended towards significance. If increasing our sample size by 7 subjects causes a trend towards significance, then it is plausible that the desired 20 subjects per cohort would have changed the results of this study. This study utilized self-reported sleep quantity and quality. These subjective reports of sleep are inherently limited as compared to more objective measurements of sleep. Subjects tend to report significantly higher sleep quantity in when self-reporting as compared to more objective measurement.[12,59] Carter et al. found that male collegiate athletes reported a significantly higher subjective sleep quantity as compared to their objective sleep quantity as measured by wristwatch actigraphy.[70] Female athletes in this study were not found to report significantly higher subjective sleep quantity as compared to their objective sleep quantity.[70] It is also possible that our subjects reported higher sleep quantity and quality purposefully. If our athletes believed their coaches would be seeing the results of this study, then they may have reported untruthful sleep to avoid reprimand from their coaches. It is impossible to know if the athletes in this study were truthful in their reports of sleep, as we have to objective measurements of sleep to compare to the subjective reports. This inconsistency between subjective and objective measures should be considered when assessing the results of this study. If subjective reports tend to increase sleep quantity, it is possible the sleep quantity reported in this study is higher than the true sleep quantity obtained by the athletes of this study. At minimum, when comparing the average sleep of athletes found in this study to other studies, the method of collection should be considered. Comparing our average sleep quantity to studies utilizing objective measurements may not be an accurate comparison. Drop out may also have been decreased using objective measurement, such as wristwatch actigraphy. If we had asked athletes to wear a wristwatch, rather than fill out a questionnaire daily, they may have been more compliant. We would not be reliant on participants remember to open and complete the questionnaire.

In this study, athletes were the only subjects utilized. No general population students were used as controls. It is possible that all three cohorts would have significantly different sleep when compared to a control group. There is little research comparing the athletic population to the general population, so it is difficult to know if athletes are gaining adequate sleep as compared to the general population.[6]

Future Research

In future research, larger sample sizes should be used. Small sample size is a common limitation in research into athletics and sleep, and this became a limiting factor in this study, as well. Completing this same study but with larger cohort sizes may reveal more differences than seen in this study. Utilizing objective measures of sleep, such as wristwatch actigraphy, would strengthen further research. Comparing practice time and sleep across more than three teams may also reveal more differences. Sleep patterns of female athletes also warrants further attention and should be incorporated into future research. Lastly, following the sleep trends of teams throughout their seasons and into the off season may reveal different sleep trends. As teams move through their seasons, schedules tend to shift to accommodate competitions, and the off season tends to allow athletes more free time to create their own schedule.

APPENDIX 1: ENTRANCE QUESTIONNAIRE

What is your age in years? _______________

1. Have you ever been diagnosed with a sleep disorder by a medical professional?
   - ☐ YES
   - ☐ NO
2. Have you ever been diagnosed with a mood disorder by a medical professional?
   - ☐ YES
   - ☐ NO
3. How often do you utilize a sleep aid?
   - ☐ NEVER
   - ☐ 1-2 NIGHTS PER WEEK
   - ☐ 3-5 NIGHTS PER WEEK
   - ☐ GREATER THAN 5 NIGHTS PER WEEK

STOP-BANG Questionnaire for Sleep Apnea

1. Do you Snore Loudly (loud enough to be heard through closed doors or your bed-partner elbows you for snoring at night)?
   - ☐ YES
   - ☐ NO
2. Do you often feel Tired, Fatigued, or Sleepy during the daytime (such as falling asleep during driving or talking to someone)?
   - ☐ YES
   - ☐ NO

3. Has anyone Observed you Stop Breathing or Choking/Gasping during your sleep?

   - ☐ YES
   - ☐ NO

4. Do you have or are being treated for High Blood Pressure?

   - ☐ YES
   - ☐ NO

5. What is your estimated height and weight?

   - ☐ HEIGHT: ______________
   - ☐ WEIGHT: ______________

6. Is your shirt collar 17 inches / 43cm or larger?

   - ☐ YES
   - ☐ NO

Email: ____

STOP-BANG score: _______ (+1 male) = ___________

APPENDIX 2: SLEEP QUANTITY AND PRACTICE PARTICIPATION QUESTIONNAIRE

What time did you go to bed last night (lights out, attempting to fall asleep)?

Hour

Minute

AM or PM?

What time did you wake up to begin your day today?

Hour

Minute

AM or PM?

My sleep quality was...

- Very bad
- Bad
- Fair
- Good
- Very good

Did you take any naps yesterday?

Yes

No

Display This Question:
If Did you take any naps yesterday? Yes Is Selected

How long, in total, did you nap yesterday?

Was there a team practice yesterday?

Yes

No

Display This Question:
If Was there a team practice yesterday? Yes Is Selected

Did you participate in this practice?

Yes

No

APPENDIX 3: SLEEP QUALITY QUESTIONNAIRE

My sleep was restless.

- Not at all
- A little bit
- Somewhat
- Quite a bit
- Very much

I was satisfied with my sleep.

- Not at all
- A little bit
- Somewhat
- Quite a bit
- Very much

My sleep was refreshing.

- Not at all
- A little bit
- Somewhat
- Quite a bit
- Very much

I had difficulty falling asleep.

- ○ Not at all
- ○ A little bit
- ○ Somewhat
- ○ Quite a bit
- ○ Very much

I had trouble staying asleep.

- ○ Never
- ○ Rarely
- ○ Sometimes
- ○ Often
- ○ Always

I had trouble sleeping.

- ○ Never
- ○ Rarely
- ○ Sometimes
- ○ Often
- ○ Always

I got enough sleep.

- Never
- Rarely
- Sometimes
- Often
- Always

My sleep quality was...

- Very Poor
- Poor
- Far
- Good
- Very Good

APPENDIX 4: EXIT QUESTIONNAIRE

In the LAST FOUR (4) WEEKS...

How often did you consume alcohol?

- Never
- 1-2 times per week
- 3-5 times per week
- More the 5 times per week

How often did you utilize a sleep aid?

- Never
- 1-2 times per week
- 3-5 times per week
- More than 5 times per week

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